Overview

This document is intended to help those who design and specify insulation thickness on low temperature piping systems. The information provided here is applicable to most all rigid cellular foam materials utilizing blowing agents to enhance thermal properties. The data provided is specific to Owens Corning™ FOAMULAR®. Other manufacturer’s products have unique properties and should be contacted for their specific information.

Background

The use of computer models for calculating insulation thickness has been practiced since the earliest computers where made commercially available. Early on, insulation manufacturers did the calculations for each product and provided the thickness information to the requesting party. Over time, with the expansion of computers, the calculations have moved from the manufacturers to the designers. The majority of this work has been done on the hot side, 32°F and up.

The cold side thickness calculations have continued to remain primarily with the insulation manufacturers. There are two main contributors to this trend:

• The first is the relative size of the “cold side” market. It is much smaller than the hot side.
• The second, and most significant, is the impact of blowing agents on the insulation’s thermal conductivity in the cold side operating range.

Blowing agents are used in rigid cellular foams to enhance thermal performance. Each blowing agent has a specific boiling point. When the boiling point temperature is reached, the thermal properties of the BA gas and in turn the foam are impacted. This must be taken into consideration when calculating insulation thickness when the operating range encompasses the boiling point.

ASTM C680 – 3E Plus Software

ASTM (formerly The American Standards for Testing and Materials) has developed a standard calculation for determining insulation thickness across a broad range of materials and process parameters. Most every insulation manufacturer has developed basic charts for their products using these calculations to assist designers.

NAIMA (North American Insulation Manufacturers Association) has developed a computer program 3E Plus based on the ASTM C680 calculations. This program is free and can be downloaded from their website.

The software includes a host of preloaded data for different pipe, insulation, and jacketing materials all relevant to the thickness calculations. In addition, the user can input data for other materials as needed.

There is a disclaimer in the ASTM C680 standard related to the blowing agent boiling point issue with cold side rigid cellular foam.

For example, the condensation of the gaseous portions of thermal insulation in extremely cold conditions will have an extremely influential effect on the apparent thermal conductivity of the insulation. With all of this considered, the use of a single value of thermal conductivity at an arithmetic mean temperature will provide less accurate predictions, especially when bridging temperature regions where strong temperature dependence occurs.

It is extremely important to have thermal data through the temperature range encompassing the boiling point of the blowing agent. In addition, an understanding of how the 3E Plus software uses the thermal data is also important.

The charts below show the thermal curve data for the Owens Corning™ FOAMULAR® along with the curve calculated using the 3E software (figure 1)

![Figure 1](image-url)
Calculating Thickness of FOAMULAR® Pipe Insulation

The trend line in figure 1 is what is calculated in the 3E Plus software. 3E Plus calculates a second order polynomial curve based on the data set provided. As such, the curve may not represent the data as seen in figure 1. The 3E Plus curve is most inaccurate through the 0 to -100 °F range due to the impact of the boiling point of the blowing agent. This also coincides with the operating range of most ammonia refrigeration systems.

Improving Accuracy

The resolution to the issue is relatively simple and straightforward. Create narrow subsets of data that allow the 2nd order polynomial calculation limitation in 3E Plus to more closely reflect the actual data. The chart below (figure 2) shows the same thermal curve data divided up into three data sets with high correlation to the original data.

The following data (figure 3) can be used to create three different insulation materials within the 3E Plus software. To add insulation materials, choose OPTIONS, Insulation Materials Maintenance. Select add and then choose the Polynomial Constants option in the Conductivity Data Type. Use the data below to create the three separate insulation materials.

<table>
<thead>
<tr>
<th>Name</th>
<th>FOAMULAR® XPS 0 to 160</th>
<th>FOAMULAR® XPS -100 to 0</th>
<th>FOAMULAR® XPS -297 to -100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Temp</td>
<td>160</td>
<td>0</td>
<td>-100</td>
</tr>
<tr>
<td>Min. Temp</td>
<td>0</td>
<td>-100</td>
<td>-297</td>
</tr>
<tr>
<td>Polynomial Constant A:</td>
<td>0.1643</td>
<td>0.162</td>
<td>0.1726</td>
</tr>
<tr>
<td>Polynomial Constant B:</td>
<td>0.0003</td>
<td>0.0002</td>
<td>0.0001</td>
</tr>
<tr>
<td>Polynomial Constant C:</td>
<td>1E-06</td>
<td>1E-06</td>
<td>-8E-07</td>
</tr>
</tbody>
</table>

The proper one must be chosen based on the process temperature in order to get the most accurate insulation thickness calculation. By entering the Max and Min Temps recommended above, the software will identify material outside the maximum or minimum operating range.

Additional Considerations

There are at least two additional considerations that should be taken when using the 3E software to determine insulation thickness:

- The minimum thickness that can be both fabricated and installed in the field. Thicknesses less than 1” may not be feasible even though the software may specify them.
- The preloaded thermal curve information for Type IIIX Polystyrene Insulation uses industry data from old blowing agent material. There has been at least one blowing agent change since the publishing of the existing data in the ASTM C578 (the source of the data). As such, the thermal data may not be representative of current product on the market.

Please contact 419-248-6557 for additional information. Email: gettech@owenscorning.com